Biofilms and Drinking Water Quality

By Joan B. Rose, PhD

The ability of microorganisms to attach to diverse surfaces and form complex colonies known as biofilms vastly improves their survival and growth in environmental niches. Biofilms form when bacteria adhere to surfaces by excreting a slimy, glue-like substance, and can include algae, protozoa, and other microorganisms. Nationally, biofilms cost the US billions of dollars every year in energy losses, equipment damage, product contamination, and medical infections.[1] Although we have written in the past about biofilms, the good and bad, this article focuses on their role in microbiological drinking water quality—specifically biofilms in distribution systems.

Biofilm and corrosion in a water pipe

Photo credit: *Institute of Northern Engineering – University of Alaska Fairbanks*

A Widespread Problem

All water distribution systems eventually develop some type of biofilm. Because biofilms can protect pathogenic (disease-causing) microbes from disinfection, they can present a threat to public health. Biofilms can also discolor water and cause taste and odor problems; recent research has focused on whether biofilms influence the production of disinfection byproducts during drinking water treatment. Moreover, corrosion of cast iron and ductile iron pipe and biofilm formation mutually accelerate the formation of each other, contributing to our nation's aging water infrastructure.[2]

Biofilms in Pipes

When microorganisms anchor to the inner surfaces of drinking water treatment systems, storage containers, and downstream distribution (or "premise") plumbing, the biofilms become a potential source of microbial (i.e., "regrowth") contamination of water. Public health problems associated with biofilms include *Legionella* in Flint's drinking water, *Pseudomonas* in health care facilities, or *Mycobacterium* in dental clinics. Biofilm development depends on many factors, including temperature, residual disinfectant concentrations, nutrient levels, water velocity and stagnation periods, as well as

[1] Biofilm Basics: What are biofilms? http://www.biofilm.montana.edu/node/2390.

[2] American Water Works Association (2012). Buried No Longer: Confronting America's Water Infrastructure Challenge. http://www.awwa.org/Portals/0/files/legreg/documents/BuriedNoLonger.pdf.

pipe materials.[3] Non-ferrous pipes (such as PVC/HDPE/CPVC) are not subject to corrosion[4] and thus eliminate much of the breeding ground for biofilm formation; for example, PVC pipes have at least a 100-year service life.[5]

Battling Biofilms

Fortunately, chemical and physical options are available for controlling biofilms, especially in aging drinking water systems, since total elimination is virtually impossible to achieve or maintain. Because disinfectants alone cannot eliminate biofilms, reducing nutrient levels can help reduce their growth. Further, so-called "booster disinfection" to maintain disinfectant levels throughout the water system can help. Chloramines as a secondary disinfectant for water from the treatment plant to the tap may penetrate biofilms better than chlorine alone. Physical control methods can also be effective, especially for well-established, "mature" biofilms. For example, flushing water through pipes at high velocities can help remove biofilms from smooth pipe interiors.

Controlling biofilms remains an important and challenging step in safely delivering high microbiological quality water—particularly in healthcare environments where there are many sensitive populations—and especially given the steadily advancing age of much of our nation's water infrastructure.

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[3] Rozej et al. (2015). Structure and microbial diversity of biofilms on different pipe materials of a model drinking water distribution systems. *World J. Microbiol. Biotechnol.* https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4282696/pdf/11274_2014_Article_1761.pdf.

[4] Water Research Foundation (2016). State of the Science: Plastic Pipe. http://www.waterrf.org/Pages/Projects.aspx?PID=4680.

[5] Folkman, S. (2014) PVC Pipe Longevity Report. http://www.eng.usu.edu/mae/faculty/stevef/USUPVCLongevity.pdf.